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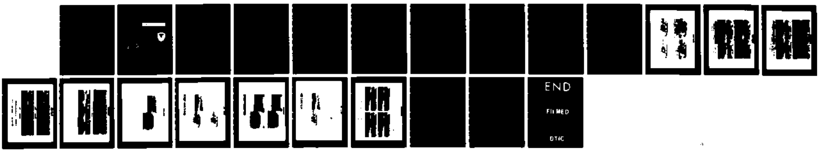

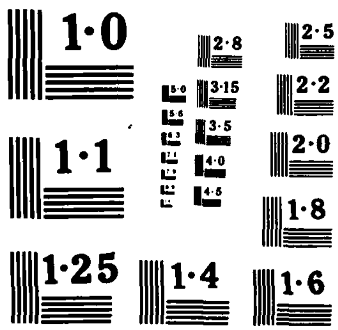
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TECHNICAL REPORT

NO. 13082

U S ARMY

TACOM

USE OF THE TACOM THERMAL IMAGING MODEL

FEBRUARY 1985

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This report outlines the basic function and architecture of the TACOM Thermal Imaging Model. Typical use of the simulation model are given as well as examples of output imagery gererated from the model.

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TABLE OF CONTENTS

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LIST OF ILLUSTRATIONS

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1.0. INTRODUCTION

This report presents output imagery from TACOM's Thermal Imaging Model (TTIM) developed by Timothy J. Rogne, Brian K. Matise and Frederick G. Smith of Optimetrics, Inc. for the U.S. Army Tank-Automotive Command (TACOM) under Contract DAAE07-81-C-4053. TTIM is capable of processing measured or modeled infrared scenes so as to account for FLIR sensor effects, natural atmospheric effects, and battlefield environment effects. This allows the operator to relate surface temperatures on the vehicle to image grey levels and vice-versa. The importance of the image simulation procedure is that the concept vehicle designer for the first time will have simulated imagery of his vehicle concept as seen through some threat sensor configuration. The relative survivability criteria for various concept vehicle designs can then be evaluated in a systematic manner.

2.0 TTIM ARCHITECTURE

A brief overview of TTIM is presented here. For detailed information on the model refer to references 1 and 2. TTIM is a menu driven program implemented on a VAX 11/750 computer system interfaced to a Comtal image processing system. Attached to the program are data libraries which provide the appropiate data for various types of sensors, atmospheric conditions and obscuring battlefield effects such as smoke or aerosols. Many of the various sub-models which make up TTIM have been validated. Validation of the model as a whole will be completed shortly.

TTIM can be divided into three submodels: the natural atmospheric effects model, the battlefield effects model and the sensor model. The natural atmospheric effects model is a version of LOWTRAN6 developed by the U.S. Air Force Geophysics Laboratory. LOWTRAN6 calculates atmospheric transmittance and radiance over .25 to 28.5 um [ref. 3]. The battlefield effects model is a version of ACTMAD developed by Optimetrics for the U.S. Army Atmospheric Sciences Laboratory (ASL). ACTMAD allows for multiple varieties of smoke munitions and smoke sources positioned in any configuration [ref.4]. ACTMAD calculates a spatial map of the obscurant cloud attenuation and path radiance. The sensor model basically consists of two parts: an optical system model and a sensor subsystem model. The sensor subsystem model utilizes the same transfer function forms as the NV&EOL Static Performance Model for Thermal Viewing Systems [ref. 5].

TTIM also has the ability to perform the inverse of the process described above. This allows the user to inverse process recorded field data to remove sensor and atmospheric effects and obtain an apparent temperature map of the scene. This unique capability can assist the vehicle designer in reducing the signature of a fielded vehicle.

3.0 TTIM APPLICATIONS

TTIM can aid in many areas of image processing and scene analysis. Immediate plans are to integrate TTIM into on-going vehicle perceptability research programs conducted at TACOM [ref. 6,7,8]. This work is concerned with improving vehicle survivability by identifying and reducing vehicle signature cue features which contribute to target detection. TTIM can provide the vehicle designer with an extremely attractive, cost effective tool for evaluating concept vehicle survivability. Applications for TTIM also include search process modeling studies of human observers to establish and confirm detection and recognition criteria. In addition, TTIM could assist in thermal sensor design and evaluation and also in evaluating smoke and weather obscurant effectiveness. TTIM can also assist in establishing sensor platform stabilization requirements.

4.0 TTIM OUTPUT IMAGERY EXAMPLES

The following pages contain examples of imagery generated via the use of TTIM. Each figure is labeled with target range, weather conditions, type of aerosol present and sensor type. Three different sensors are used in the examples. To avoid classification of this document the names of the sensors have been withheld and are referred to as SENSOR A, SENSOR B, AND SENSOR C. SENSOR A has a serial 1x14 scanning detector array and SENSOR B has a serial 2x14 scanning detector array. Both SENSOR A and SENSOR B have a f-number of 2.0 and a detector area of 4.50 x E-06 cm**2. SENSOR C has a parallel 180x1 scanning detector array, a f-number of 2.53 and a detector area of 2.58 x E-05 cm**2.

The tank scene in figure 1 illustrates the effect rain has on SENSOR C. Presently the model outputs the average effects rain has on a thermal scene. Modeled weather conditions are also assumed to be spatially symmetric. Phase II of the model will address both of these issues.

The model has zoomed on the tank in figures 2 thru 5 to show the resolution loss suffered when viewing distant targets. Later figures do not zoom on the data in this manner and therefore a distant tank appears smaller than a close tank through the same field of view lens. Figure 2 illustrates a best case scenario using SENSOR A when viewing a tank at the ranges shown. Note in this figure that at a 5 km target range even in a clear atmosphere the target is barely perceptable using this sensor. Figure 3 contains the same input image as for the 1 km case except the atmosphere has several different densities of fog.

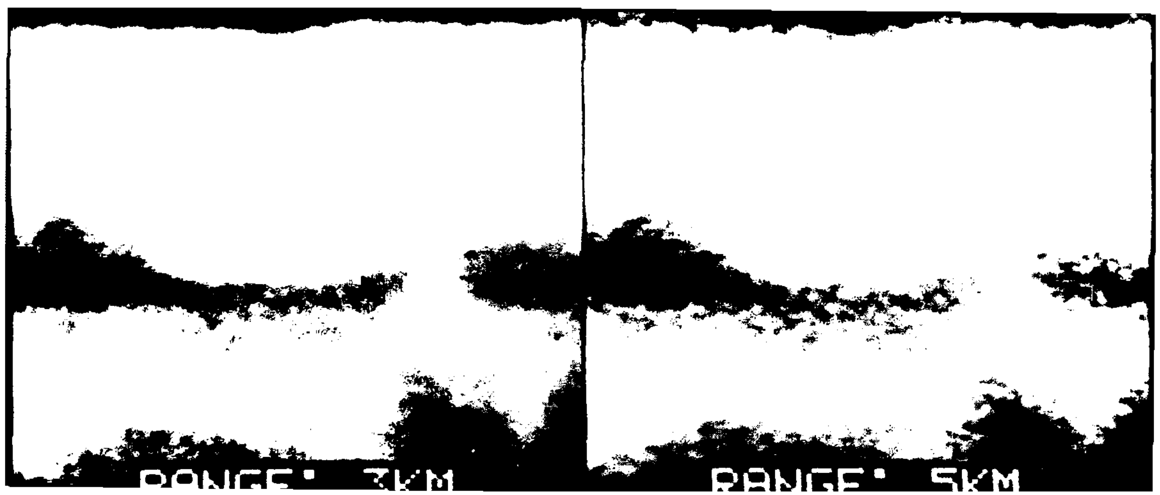
Figures 4 and 5 illustrates a performance comparison for ideal and fog atmospheres between three sensors. The figures show that at 1 km target range in a clear or thin fog atmosphere there are only slight differences between each sensor's output. Close examination

shows that SENSOR B is slightly better than SENSOR A,most likely due to the square root of two improvement in the sensor's signal to noise ratio. Similar the output using SENSOR C is of better quality than that of SENSOR B's. The differences between each sensor's output is enhanced when viewing in less favorable conditions. At 3 km target range in figures 4 and 5 the tank is much more recognizable using SENSOR C and in the ideal atmosphere case it is possibly even identifiable.

Figures 6 thru 9 represent a case study using the same three sensors and an ideal sensor viewing a tank at one and three kilometers through a clear and rainy atmosphere. In this imagery the data is scaled properly so that the tank at 1 km appears three times as large as the tank at 3 km. The same performance trends observed in figures 4 and 5 between the three sensors can be seen in figures 6 thru 9. Note that although SENSOR C appears to be a very good sensor there is a significant difference between SENSOR C's imagery in figure 9 and the ideal sensor imagery in figure 6, particular at 3 km target range.

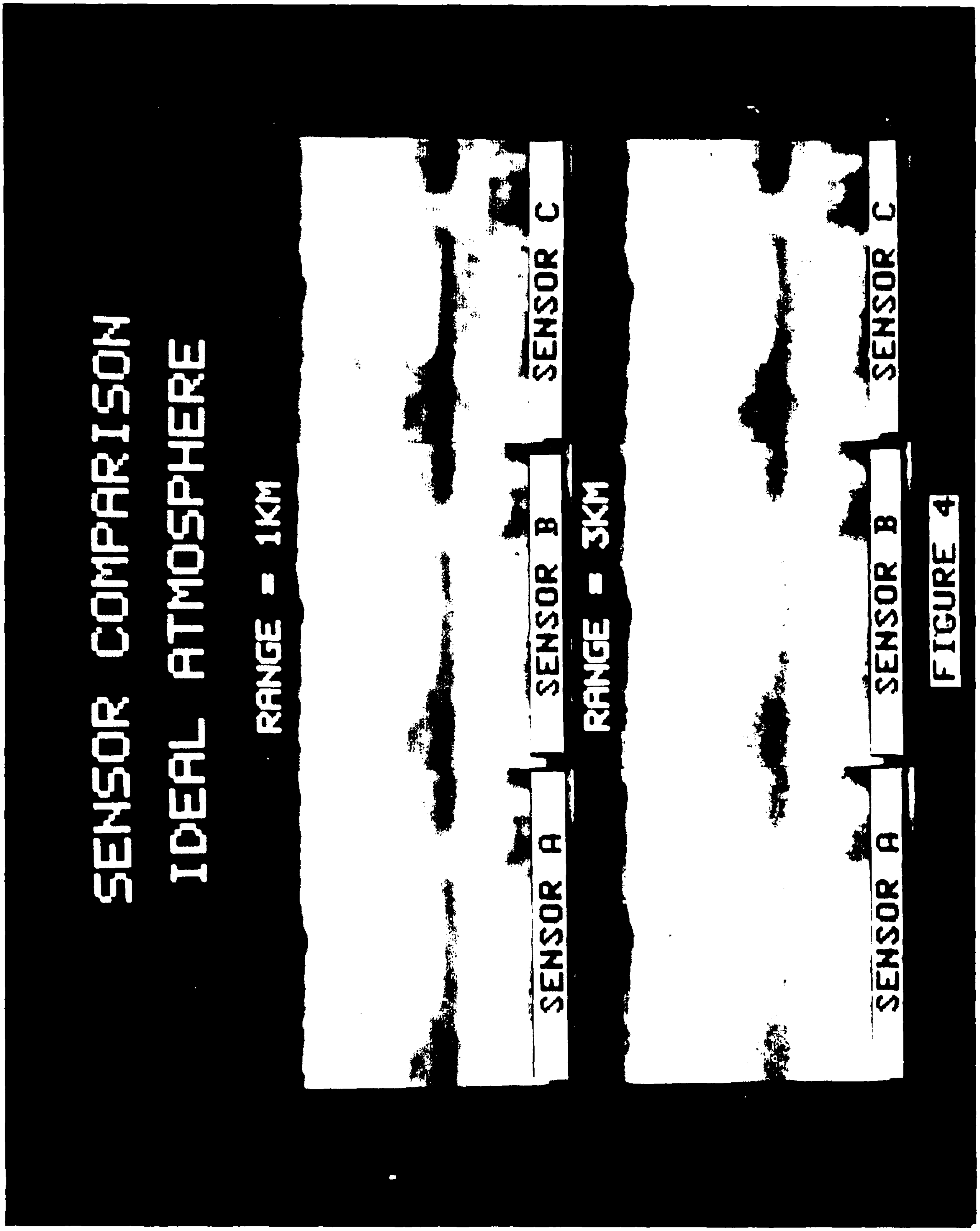
The performance of each sensor in the battlefield atmospheric effects module was also analyzed. The L8A1 and XM76 smokes grenades were set off at various distances and spacings between the sensor and the target. Final results and hard copies of these tests however were not available at the time of publication.

The model is also ideal for establishing sensor stabilization parameters. Figure 10 contains a tank at one kilometer when viewed with a sensor mounted on a non-stable platform. The imagery illustrates the degrading effect vibration at 0, 200, 400, and 600 u-radians rms can have on the sensor's performance. Even at 1 km target range as in figure 10, the vibration causes the vehicle's road wheels and smaller components to become indistinguishable. At longer target ranges, the degrading effect of sensor vibration will be increased and the vehicle's detected signature will tend to blend in more and more with the background.



RANGE: 3KM
RANGE: 5KM


2KM VISIBILITY
1KM VISIBILITY


SENSOR COMPARISON
IDEAL ATMOSPHERE
RANGE = 1KM
SENSOR A
SENSOR B
SENSOR C
RANGE = 3KM
SENSOR A
SENSOR B
SENSOR C
FIGURE 4

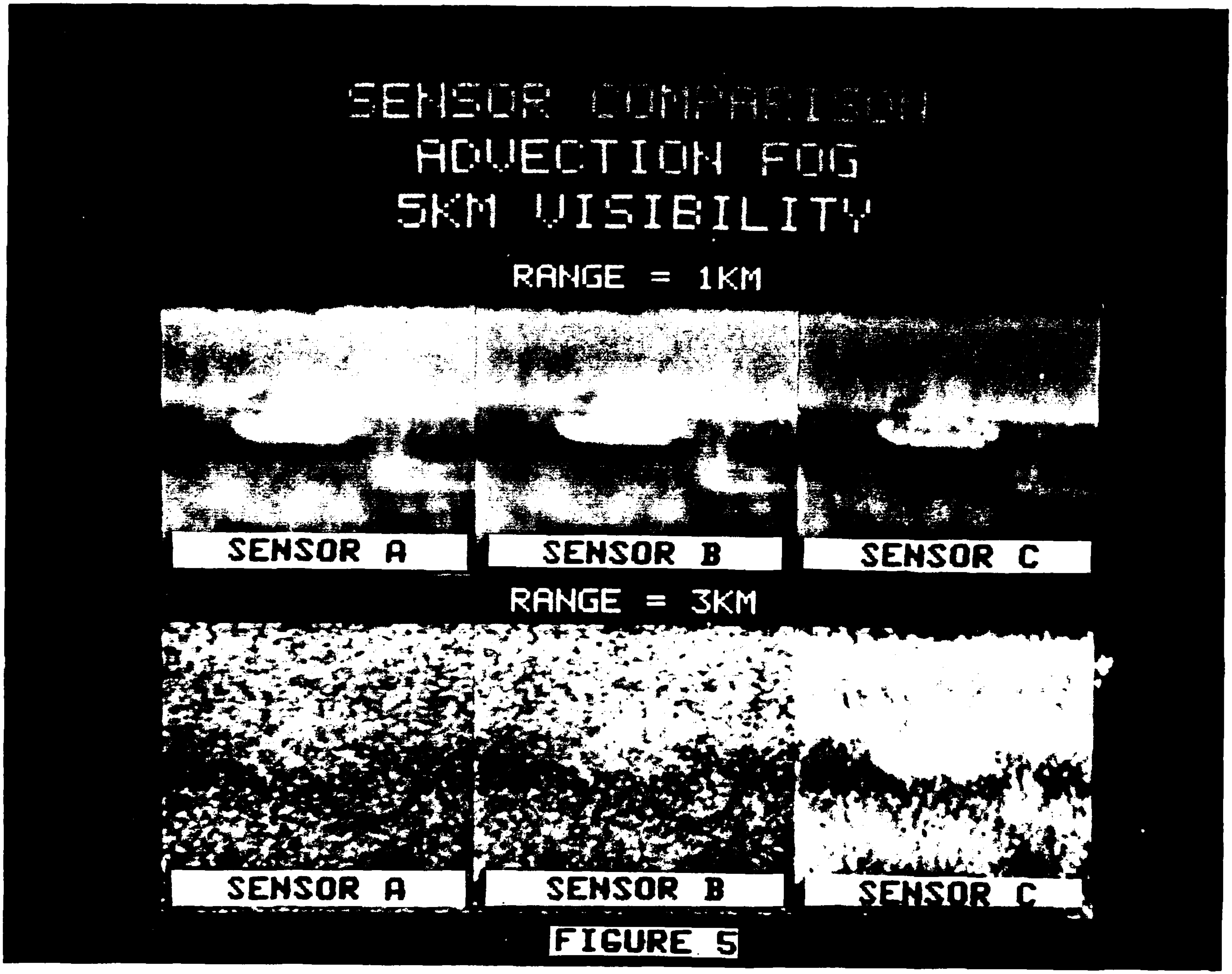

SENSOR COMPARISON
ADVECTION FOG
5KM VISIBILITY
RANGE = 1KM
SENSOR A
SENSOR B
SENSOR C
RANGE = 3KM
SENSOR A
SENSOR B
SENSOR C

FIGURE 5

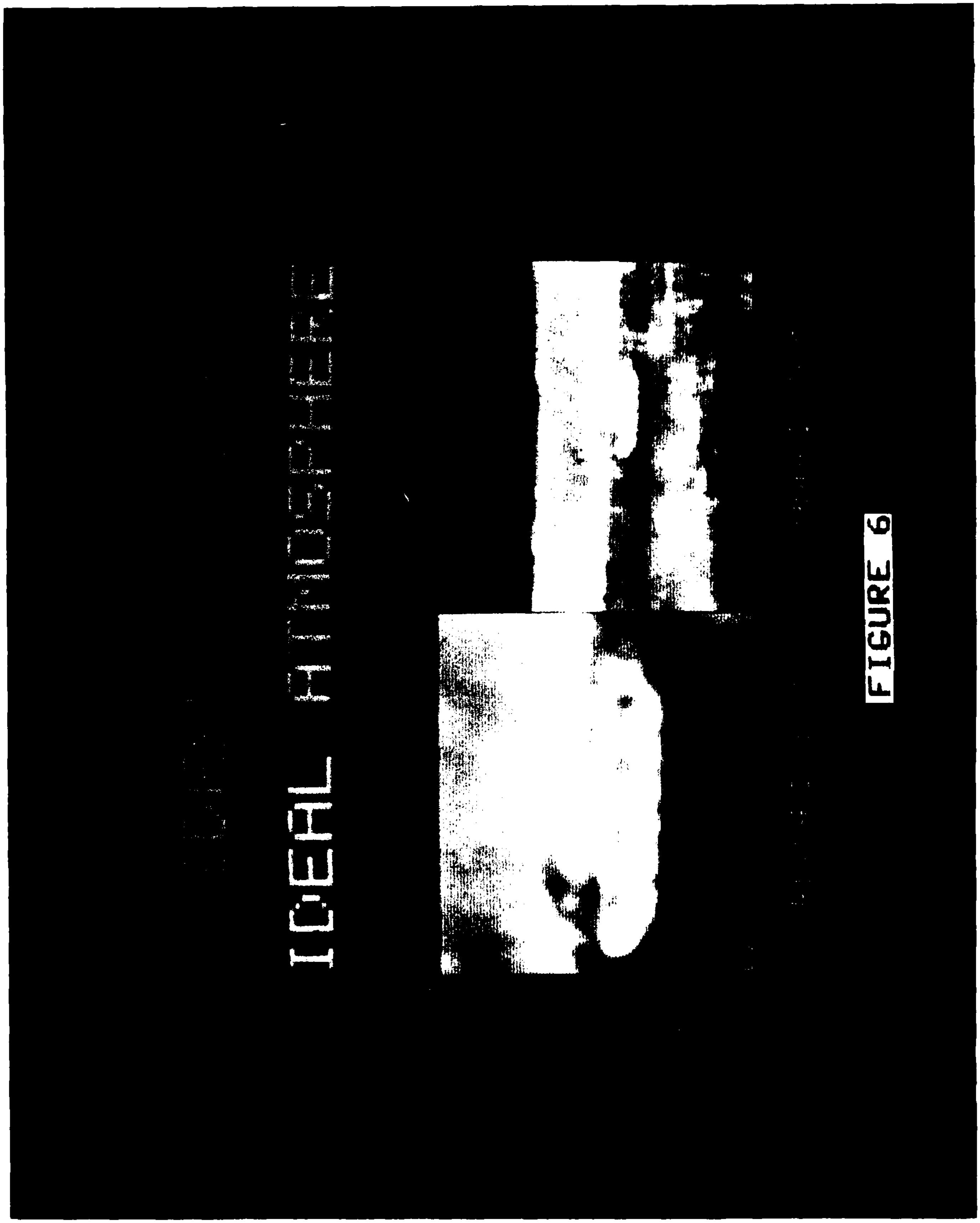


FIGURE 6

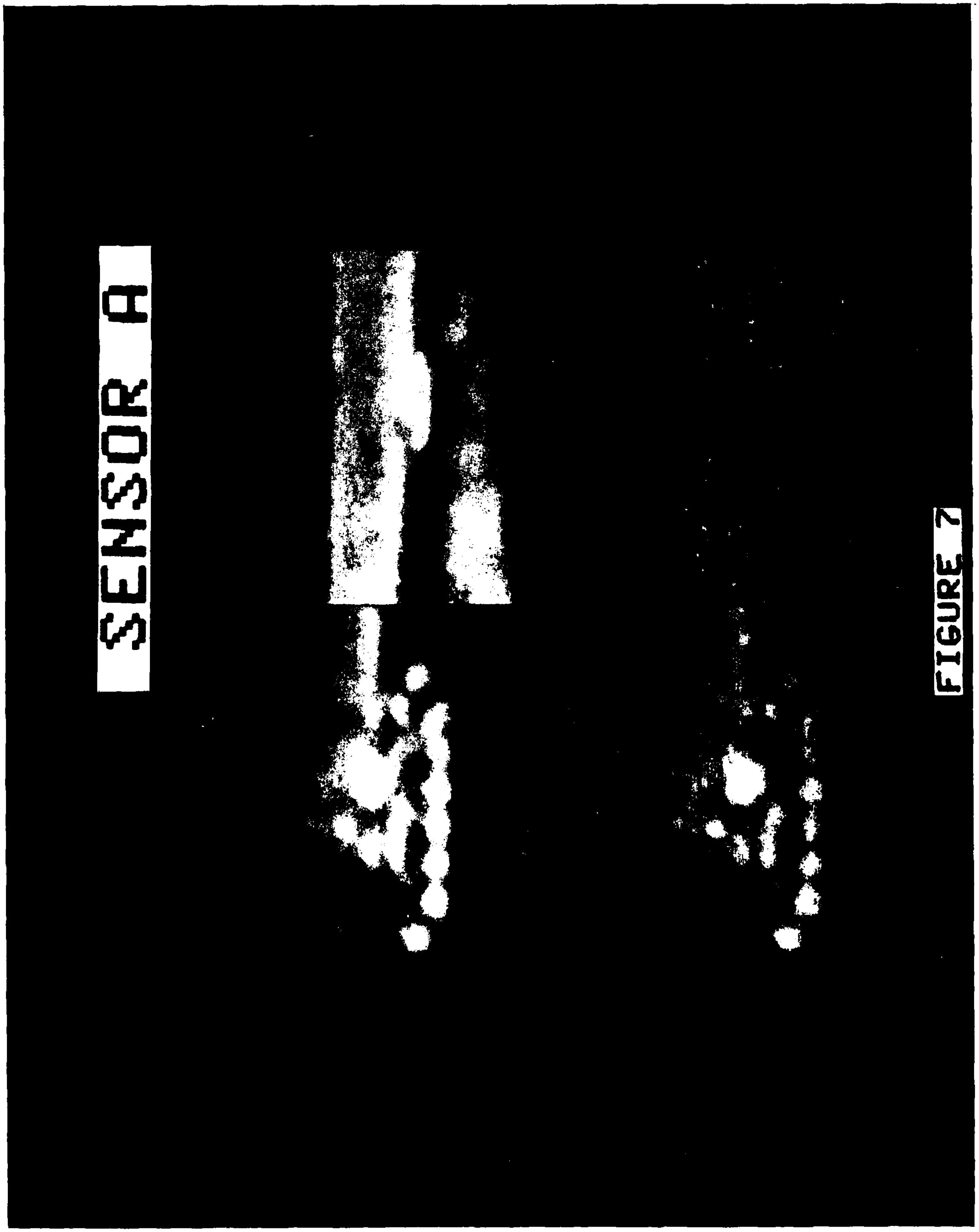


FIGURE 7

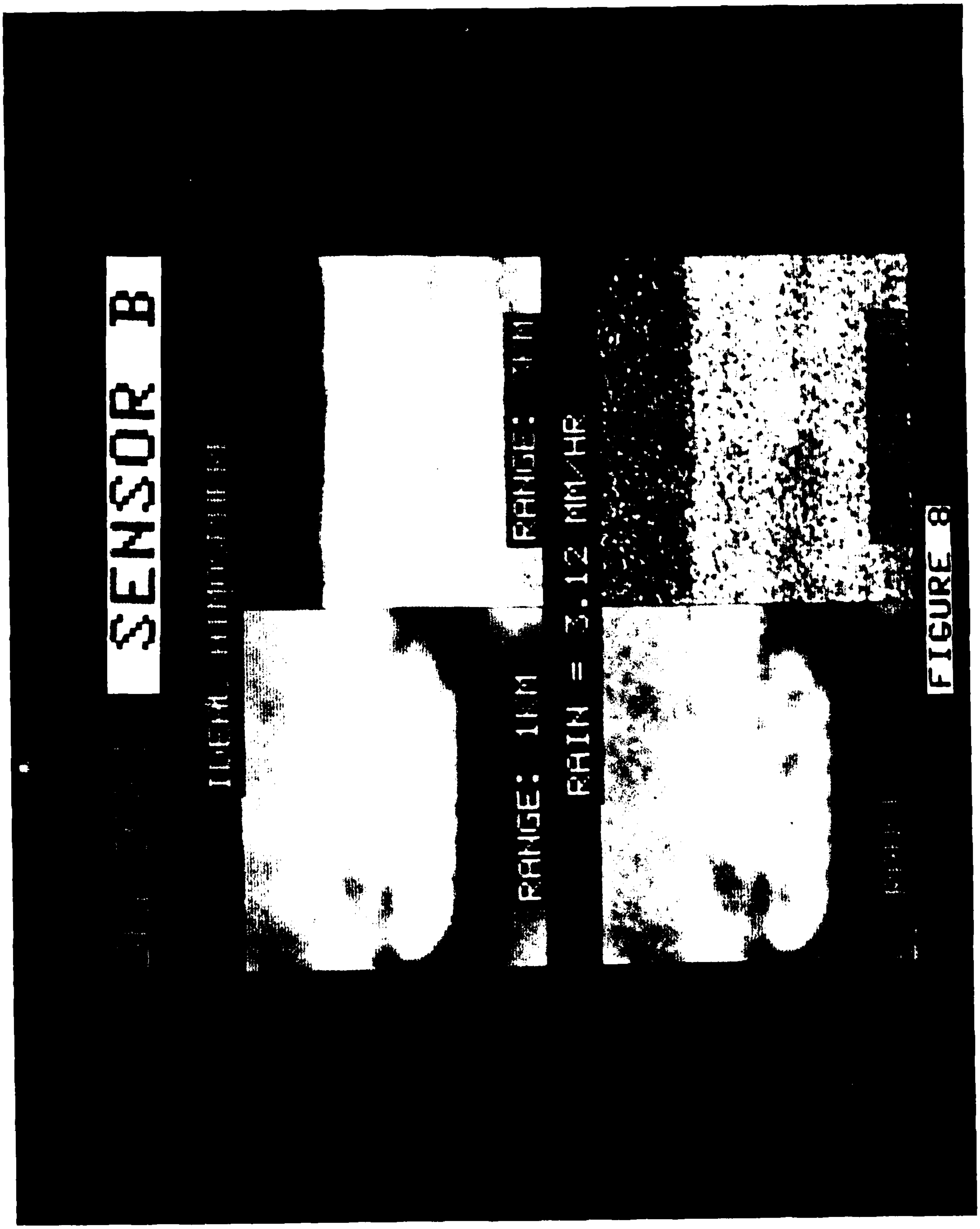


FIGURE 8

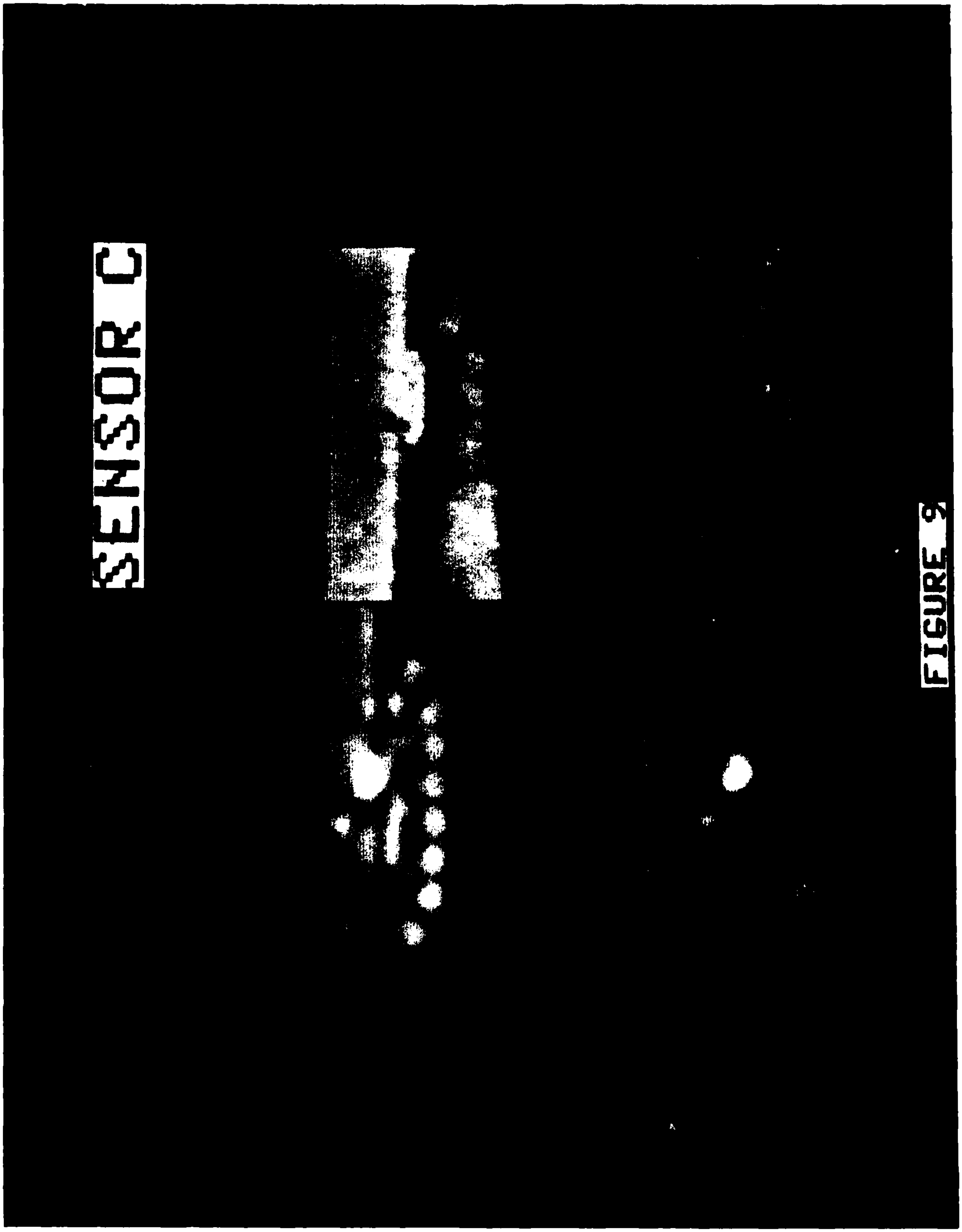


FIGURE 9

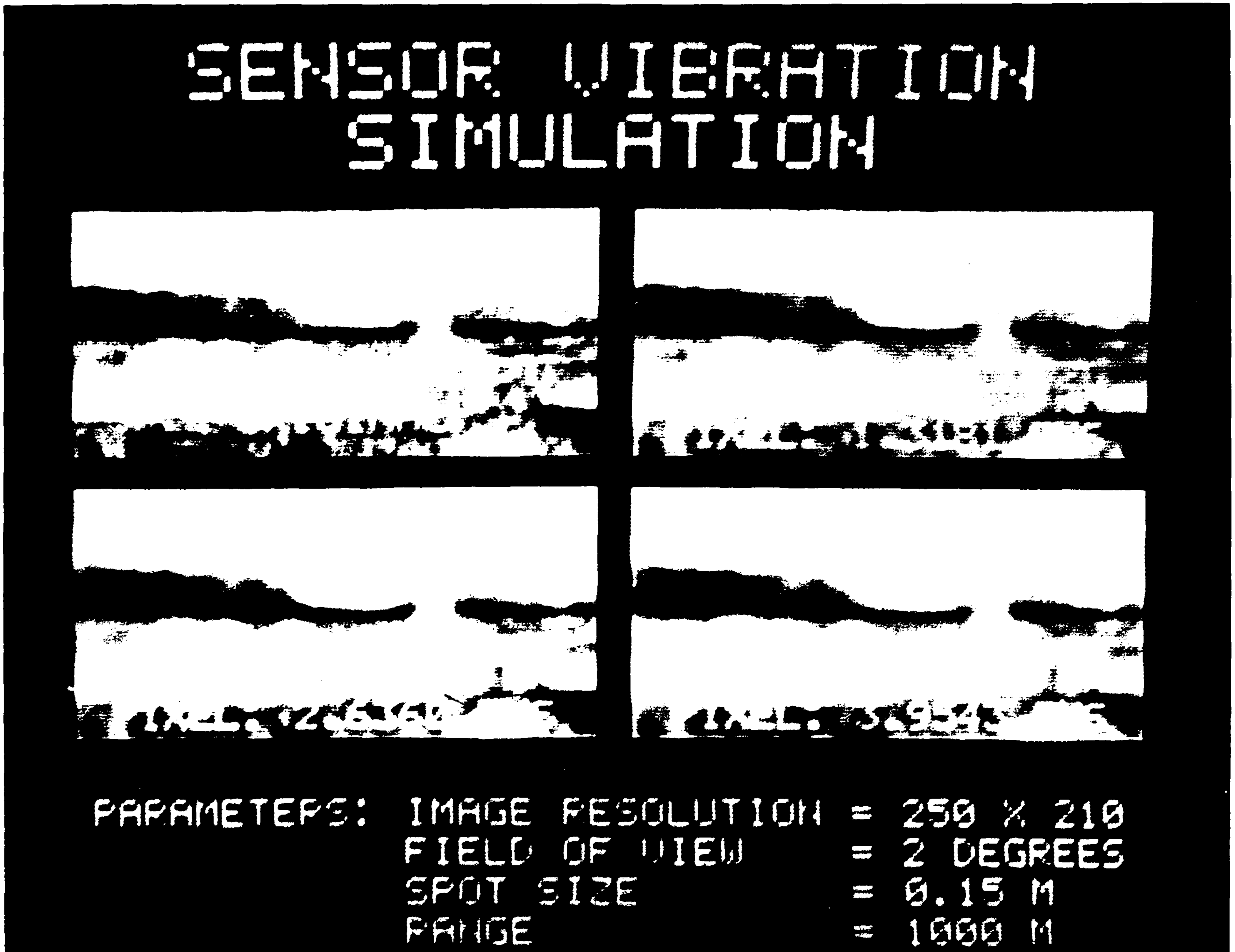

SENSOR VIBRATION
SIMULATION
PARAMETERS: IMAGE RESOLUTION = 250 X 210
FIELD OF VIEW = 2 DEGREES
SPOT SIZE = 0.15 M
RANGE = 1000 M

FIGURE 10

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8. G.R. Gerhart, J.M. Graziano, D.J. Thomas, J.A. Dumas, "Thermal Cue Feature Analysis", Proceedings of the 1984 KRC Signature Symposium, Vol. 1, August,1984.

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